

USRE035590: Solid state event recorder

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Abstract:

A solid state event recorder having particular application to railroad locomotives has a plurality of interface modules to allow the collection of desired data over a period of time. Radio downloading of the data provided by a telemetry transmitter to wayside receivers is the primary way of downloading data. Alternative data downloading are provided by a removable memory module, a portable wireless data extractor and a laptop computer. The removable memory module is provided with its own backup battery power supply but normally derives its power from an inductive coupling to the solid state recorder. Data is read into the removable memory module from the solid state recorder via an inductive coupling, and data is read out of the removable memory module to the telemetry transmitter via another inductive coupling. Both the portable wireless data extractor and the laptop computer are used for maintenance purposes. The solid state recorder can be configured in a variety of ways and connected together as master and slave. For example, one recorder, acting as a master and functioning as the primary of operational recorder, can be connected to a second recorder, acting as a slave time synchronized with the first recorder. This second recorder can serve as a maintenance recorder for collecting long term data and trouble shooting a particular locomotive.

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We claim:

- ~~—1. A solid state event recorder for mounting in and monitoring events on a vehicle comprising:~~
- ~~• a plurality of event inputs for receiving analog and digital data to be recorded;~~
 - ~~• interface means connected to said event inputs for buffering digital inputs and converting analog inputs to digital values;~~
 - ~~• first microprocessor means connected to said interface means for formatting data provided by said interface means;~~
 - ~~• memory means coupled to said first microprocessor means for receiving and recording formatted data, said memory means including an array of solid state memory devices, and second microprocessor means in communication with said first microprocessor means for receiving formatted data and recording the formatted data in said array of solid state memory devices;~~
 - ~~• a telemetry transmitter for transmitting data recorded in said memory means;~~
 - ~~• telemetry control means interposed between said first microprocessor means and said memory means and between said memory means and said telemetry transmitter, said first microprocessor means controlling said telemetry control means to prevent transmitting data while formatted data is being recorded in said memory means; and~~
 - ~~• a plurality of telemetry receivers located along a path of motion of said vehicle, each of said telemetry receivers receiving transmitted data as said vehicle passes by.~~
- ~~2. The solid state event recorder as recited in [claim 1](#) further comprising a portable wireless receiver for positioning proximate said telemetry transmitter to download data recorded in said memory means.~~
- ~~3. The solid state event recorder as recited in [claim 1](#) further comprising a portable computer for connection to said solid state recorder to download data recorded in said memory means.~~
- ~~4. The solid state event recorder as recited in [claim 1](#) wherein said memory means is removable and includes batteries for powering said array of solid state memory devices and said second microprocessor means when said memory means is removed from said solid state event recorder and further comprising inductive interface means between said solid state recorder and said memory means for transferring power to said memory means from said solid state event recorder and for transferring data between said memory means and said solid state event recorder.~~
- ~~5. The solid state event recorder as recited in [claim 4](#) wherein said inductive interface means comprises:~~
- ~~• first, second and third ferrite core pairs, each core pair having a primary winding and a secondary winding wound on a respective one of said cores, said cores of each pair being positioned for alignment with one another when said removable memory means is inserted in said solid state recorder;~~
 - ~~• oscillator means connected to the primary winding of said first core pair for inductively coupling alternating current power to the secondary winding of said first core pair;~~
 - ~~• rectifier means connected to the secondary winding of said second core pair for producing a rectified direct current voltage;~~
 - ~~• first phase splitter and driver means connected to the primary winding of said second core pair for coupling data signals from said second microprocessor means to the secondary winding of said second core pair; and~~
 - ~~• second phase splitter and driver means connected to the primary winding of said third core pair for coupling data signals from said memory means to~~
- ~~the secondary winding of said third core pair.~~
- ~~6. The solid state event recorder as recited in [claim 1](#) further comprising inductive interface means between said solid state recorder and said memory means for transferring power to said memory means from said solid state event recorder and for transferring data between said memory means and said solid state event recorder.~~
- ~~7. The solid state event recorder as recited in [claim 6](#) wherein said inductive interface means comprises:~~

- ~~first, second and third ferrite core pairs, each core pair having a primary winding and a secondary winding wound on a respective one of said cores, said cores of each pair being positioned for alignment with one another when said removable memory means is inserted in said solid state recorder;~~
- ~~oscillator means connected to the primary winding of said first core pair for inductively coupling alternating current power to the secondary winding of said first core pair;~~
- ~~rectifier means connected to the secondary winding of said second core pair for producing a rectified direct current voltage;~~
- ~~first phase splitter and driver means connected to the primary winding of said second core pair for coupling data signals from said second microprocessor means to the second winding of said second core pair; and~~
- ~~second phase splitter and driver means connected to the primary winding of said third core pair for coupling data signals from said memory means to the secondary winding of said third core pair.~~8. The solid state event recorder as recited in [claim 1](#) wherein said recorder is installed on a locomotive of a railroad train and connected to monitor and record events on said locomotive, said recorder being configured as a primary recorder, said plurality of event inputs including brake pipe air pressure, traction motor current, and an axle drive signal proportional to locomotive speed.9. The solid state event recorder as recited in [claim 8](#) further including engineman monitoring means connected to said recorder.10. The solid state event recorder as recited in [claim 8](#) wherein said event inputs further include a receiver for receiving transmission from an end of train telemetry transmitter, said receiver providing data signals proportional to brake pipe pressure at the end of the train.11. The solid state event recorder as recited in [claim 10](#) wherein said receiver further provides data signals marking a beginning and an end of a measured distance, said first microprocessor means being programmed to compute and store wheel calibration data based on said data signals and said axle drive signal, said solid state recorder further comprising speed indicator output means for providing a calibrated signal output as a function of said wheel calibration data.12. The solid state event recorder recited in [claim 8](#) further comprising a second solid state event recorder connected as a slave to said primary recorder and time synchronized therewith, said second recorder being used to record data for maintenance and troubleshooting said locomotive and having a plurality of event inputs including oil and water temperature, main generator current and voltage, and air filter flow.13. The solid state event recorder recited in [claim 1](#) wherein said memory means includes a time of day clock, the data recorded in said memory means including time

~~—of day.~~

14. A solid state event recorder *and reproduction system*, comprising:

- a plurality of event inputs for receiving analog and digital data to be recorded;
- *an* interface ~~means~~ connected to said event inputs for buffering digital inputs and converting analog inputs to digital values;
- *a* microprocessor ~~means~~ connected to said interface ~~means~~ for formatting data provided by said interface ~~means~~;
- *a* memory ~~means~~ coupled to said microprocessor ~~means~~ for receiving and recording formatted data, ~~said memory means including~~ ;
- a time of day clock, *operatively coupled to said memory, for measuring a time of said event inputs and for time indexing said formatted data*;
- playback means, *operatively coupled to said memory, for* interfacing with said memory ~~means~~ and playing back data recorded in said memory ~~means, said playback means including; and~~
- a real time clock *and operatively coupled to said playback means, said playback means* computing a time error as a difference between said time of day clock and said real time clock, said

formatted data being indexed by said time error. 15. A solid state recorder *and reproduction system*, comprising:

- a plurality of event inputs for receiving analog and digital data to be recorded;
- *an* interface ~~means~~ connected to said event inputs for buffering digital inputs and converting analog inputs to digital values;
- *a* microprocessor ~~means~~ connected to said interface ~~means~~ for formatting data provided by said interface ~~means~~;
- *a* memory ~~means~~ coupled to said microprocessor ~~means~~ for receiving and recording formatted data, ~~said memory means including~~;
- a time of day clock, *operatively coupled to said memory, for measuring a time of said event inputs and for time indexing said formatted data*;
- downloading means, *operatively coupled to said memory*, for interfacing with said memory ~~means~~ and downloading data recorded in said memory ~~means, said downloading means including~~; *and*
- a real time clock *operatively coupled to said downloading means, said downloading means and* computing a time error as a difference between said time of day clock and said real time clock, said

formatted data being indexed by said time error. 16. A solid state event recorder *and reproduction system*, for ~~mounting in and~~ monitoring events in a vehicle comprising:

- a plurality of event inputs for receiving analog and digital data representing events in said vehicle to be recorded;
- *an* interface
- ~~means~~ connected to said event inputs for buffering digital inputs and converting analog inputs to digital values;
- *a* microprocessor ~~means~~ connected to said interface ~~means~~ for formatting data provided by said interface ~~means~~;
- *a* solid state memory ~~means~~ coupled to said microprocessor ~~means~~ for receiving and recording formatted data; ~~and~~
- downloading means, *operatively coupled to said solid state memory*, for downloading data from said solid state memory ~~means, wherein said solid state memory includes~~;
- a time of day clock *operatively coupled to said downloading means and to said solid state memory*, the data recorded in said solid state memory including the time of day, ~~and said downloading means includes~~; *and*
- a real time clock ~~and computes~~ *operatively coupled to said downloading means, said downloading means computing* a time error as a difference between said time of day clock and said real time clock,

said *formatted* data being indexed by said time error. 17. The solid state event recorder *and reproduction system* as recited in [claim 16](#) further including ~~transmitting means a transmitter~~, *operatively coupled to said solid state memory*, for transmitting *formatted* data stored in said solid state memory and wherein said downloading means ~~is~~ *comprises* a portable wireless receiver for positioning proximate to said solid state ~~recorder memory~~ to

download data recorded in said solid state memory. 18. The solid state event recorder *and reproduction system* as recited in [claim 16](#) further including *a memory* interface ~~means~~ and wherein said downloading means is removably connectable to said *memory* interface ~~means~~, said *memory* interface ~~means~~ providing a path for downloading data

recorded in said solid state memory. 19. The solid state event recorder *and reproduction system* as recited in [claim 16](#) ~~wherein said solid state memory includes further including~~ a time of day clock *for producing time of day data*, the data recorded in said solid state memory including the time of day *data*, and said downloading means includes a real time clock and computes a time error as a difference between said *time of day data produced by said* time of day clock and

said real time of day data produced by said real time clock, said data being

indexed by said time error. 20. In a solid state event recorder for ~~mounting-in-and~~ monitoring events in a vehicle, said solid state event recorder comprising a plurality of event inputs for receiving analog and digital data to be recorded, *an* interface ~~means~~ connected to said event inputs for buffering digital inputs and converting analog inputs to digital values, *a* first microprocessor ~~means~~ connected to said interface ~~means~~ for formatting data provided by said interface ~~means~~, and *a* removable solid state memory ~~means~~ coupled to said first microprocessor ~~means~~ for receiving and recording formatted data, said solid state memory ~~means~~ being physically removable for playback of recorded data separate from said solid state *event* recorder, the improvement comprising:

- an array of solid state memory devices and a second microprocessor ~~means~~ in said removable *solid state memory means*, *said second microprocessor means receiving data from said first microprocessor means and recording said data in said array of solid state memory devices, said data being directly transmitted between said first and second microprocessor means* microprocessors as digital signals; and
- an inductive interface ~~means~~ between said removable solid state memory ~~means~~ and said first microprocessor ~~means~~ for transferring data at baseband between said first microprocessor ~~means~~ and said second microprocessor ~~means~~ and for coupling power from said solid state event recorder to said removable solid state

memory means. 21. The improvement in the solid state event recorder recited in [claim 20](#) wherein said inductive interface ~~means~~ comprises first, second and third ferrite core pairs, each core pair having a primary winding and a secondary winding wound on a respective one of said cores, said cores of each pair being positioned for alignment with one another when said removable solid state memory ~~means~~

is inserted in said solid state event recorder. 22. The improvement in the solid state event recorder recited in [claim 21](#) wherein said solid state event recorder further comprises a case having an opening for receiving said removable solid state memory ~~means~~, a spring biased movable plate within said opening having mounted therein a first core of each pair, said removable solid state memory ~~means~~ comprising a housing adapted to fit within said opening and having a face mating with said movable plate and having mounted therein a second core of each pair, said first and second cores of each pair being in alignment when said housing is inserted into

said opening. 23. The improvement in the solid state event recorder recited in [claim 21](#) further comprising:

- an oscillator ~~means~~ connected to the primary winding of said first core pair for inductively coupling alternating current power to the secondary winding of said first core pair;
- a rectifier ~~means~~ connected to the secondary winding of said second core pair for producing a rectified direct current voltage;
- a first phase splitter and driver ~~means~~ circuit connected to the primary winding of said second core pair for coupling data signals from said first microprocessor ~~means~~ to the secondary winding of said second core pair; and
- a second phase splitter and driver ~~means~~ circuit connected to the primary winding of said third core pair for coupling data signals from said removable solid state memory ~~means~~ to the secondary winding of said third core

pair. 24. In a solid state event recorder ~~of the type mounted-in-and~~ for monitoring events in a vehicle, said solid state event recorder comprising a plurality of event inputs for receiving analog and digital data to be recorded, an interface ~~means~~ connected to said event inputs for buffering digital inputs and converting analog inputs to digital values, a first microprocessor ~~means~~ connected to said interface ~~means~~ for formatting data provided by said interface ~~means~~, *said a* solid state memory ~~means~~ coupled to said first microprocessor ~~means~~ for receiving and recording

formatted data, said solid state memory ~~means~~ being electrically isolated from said solid state event recorder, the improvement comprising:

- an array of solid state memory devices and a second microprocessor ~~means~~ in said solid state memory ~~means~~, said second microprocessor ~~means~~ receiving data from said first microprocessor ~~means~~ and recording said data in said array of solid state memory devices, said data being directly transmitted between said first and second ~~microprocessor means~~ microprocessors as digital signals; and
- an inductive interface ~~means~~ between said solid state memory ~~means~~ and said first microprocessor ~~means~~ for transferring data between said first microprocessor ~~means~~ and said second microprocessor ~~means~~ and for coupling power from said solid state event recorder to said solid state

memory ~~means~~. 25. The improvement in the solid state event recorder recited in [claim 24](#) wherein said inductive interface ~~means~~ comprises first, second and third ferrite core pairs, each core pair having a primary winding and a secondary winding wound on a respective one of said cores, said cores of each pair being positioned for alignment with

one another. 26. The improvement in the solid state event recorder recited in [claim 25](#) further comprising:

- an oscillator ~~means~~ connected to the primary winding of said first core pair for inductively coupling alternating current power to the secondary winding of said first core pair;
- a rectifier ~~means~~ connected to the secondary winding of said second core pair for producing a rectified direct current voltage;
- a first phase splitter and driver ~~means~~ circuit connected to the primary winding of said second core pair for coupling data signals from said first microprocessor ~~means~~ to the secondary winding of said second core pair; and
- a second phase splitter and driver ~~means~~ circuit connected to the primary winding of said third core pair for coupling data signals from said solid state memory

~~means~~ to the secondary winding of said third core pair. 27. A solid state event recorder and reproduction system according to [claim 16](#) further comprising at least one receiver located along a path of motion of said vehicle, said at least one receiver receiving transmitted data from said downloading means as said vehicle passes by said at least one

receiver. 28. A solid state event recorder and reproduction system for monitoring events in a vehicle comprising:

- a plurality of event inputs for receiving analog and digital data representing events in said vehicle to be recorded;
- an interface connected to said event inputs for buffering digital inputs and converting analog inputs to digital values;
- a microprocessor connected to said interface for formatting data provided by said interface;
- a solid state memory coupled to said microprocessor for receiving and recording formatted data;
- timekeeping means, operatively coupled to said solid state memory, for establishing an elapsed time of said events in said vehicle corresponding to said formatted data, said solid state memory additionally storing elapsed time data of said events in said vehicle corresponding to said formatted data;
- downloading means for downloading data from said solid state memory, said downloading means including at least one receiver along a route of said vehicle for receiving said formatted data from said solid state memory; and
- means, operatively coupled to said solid state memory and to said downloading means, for correlating said elapsed time of said events in said vehicle corresponding to said

formatted data, to a real time of day, said correlating means including means for providing said real time of day,

- wherein said correlating means includes a realtime clock and means for computing said real time of day as a difference between said elapsed time and said realtime clock, said formatted data being indexed by said real*

time of day. 29. A solid state event recorder and reproduction system according to [claim 28](#), wherein said downloading means includes a transmitter, operatively coupled to said solid state memory, for transmitting said formatted data to said at least one receiver along

said route of said vehicle. 30. A solid state event recorder and reproduction system for monitoring events in a vehicle comprising:

- a plurality of event inputs for receiving analog and digital data representing events in said vehicle to be recorded;*
- an interface connected to said event inputs for buffering digital inputs and converting analog inputs to digital values;*
- a microprocessor connected to said interface for formatting data provided by said interface;*
- a solid state memory coupled to said microprocessor for receiving and recording formatted data;*
- timekeeping means, operatively coupled to said solid state memory, for establishing an elapsed time of said events in said vehicle corresponding to said formatted data, said solid state memory additionally storing elapsed time data of said events in said vehicle corresponding to said formatted data;*
- downloading means for downloading data from said solid state memory, said downloading means including at least one receiver along a route of said vehicle for receiving said formatted data from said solid state memory; and*
- means, operatively coupled to said solid state memory and to said downloading means, for correlating said elapsed time of said events in said vehicle corresponding to said formatted data, to a real time of day, said correlating means including means for providing said real time of day,*
- wherein said timekeeping means is operatively coupled to said microprocessor for establishing said elapsed time of said events over a real time of day,*
- wherein said timekeeping means includes a time of day clock for generating a time of day,*
- wherein said downloading means includes means for computing the real time of the day as a difference between said elapsed time and said time of day.*

31. A solid state event recorder and reproduction system according to [claim 30](#), wherein said data is indexed by and correlated with said time of day.